THE METHODOLOGY FOR CREATING WORKSHEETS FOR INTEGRATED SCIENCE

Markéta Bartoňová
Charles University, Czech Republic
E-mail: marketa.bartonova@gmail.com

Dana Kričfaluši
University of Ostrava, Czech Republic
E-mail: dana.kricfalusi@osu.cz

Abstract

Integrated teaching is teaching in which the educational contents of subjects are interconnected. Connections can be discussed in a specialized integrated subjects e.g., Integrated science. Integrated science is a subject that connects knowledge from chemistry, biology, physics, geography, and geology. One topic is discussed from a different point of view, and students should transform their theoretical knowledge in practice. Worksheets can serve as a teaching material that can provide help to students as well as teachers and guide students on their path to knowledge. But how should a worksheet look like and how should the tasks be designed? This contribution describes a suggested method for making a worksheet for integrated (science) teaching that we call CCCTER. CCCTER is abbreviation for choose, connect, create, try, evaluate, remade. The method implements the national Framework education program for secondary general education (grammar schools) in the process of making the tasks. The principles choose, connect, and create are demonstrated. It provides a sample task of a worksheet for integrated (science) teaching.
Keywords: *methodology for creating worksheets, integrated science, integrated teaching*

Introduction

Integrated teaching is a term that is not firmly entrenched in the literature. In our research we define integrated teaching as teaching in which the educational contents of subjects are interconnected "while the integrated educational content follows the aims of all integrated subjects. At the same time, a new aim is formed, which results from the integrated whole" (Rakoušová, 2008, p. 15). "It implements interdisciplinary relationships and a connection between theoretical and practical activities" (Průcha et al., 2001, p. 87). We perceive integrated teaching as The Integrated Model from publication Ten ways to Integrate Curriculum written by Robin Fogarty (1991). In this publication in The Integrated Model "interdisciplinary topics are rearranged around overlapping concepts and emergent patterns and designs. The integration sprouts from within the various disciplines, and teachers make matches among them as commonalities emerge" (Fogarty, 1991, p. 64).

https://doi.org/10.33225/BalticSTE/2021.07

According to the research made in 2020 in the Moravian-Silesian region of the Czech Republic (Bartoňová & Kričfaluši, 2020) a total of 66,4 % of secondary school teachers, that were part of the survey, think that they do include integrated teaching into their lessons. The second most common way of doing it was by modules or topics that are included as a part of more subjects. A total of 33.6 % of respondents think that they do not include integrated teaching into their lessons and the third most common reason for that is (according to the respondents) lack of didactic materials. Also, the research shows that the teachers may not understand the term integrated teaching correctly and most probably confused it with inter-subjects' relations. Further research is needed to confirm that.

As well as integrated teaching a worksheet is hard to define by one source. One definition is that "a worksheet is a set of tasks, exercises, didactic image material etc., that usually serves to independent student practice or provides him with a guide to his work" (Čapek, 2015, p. 124). The Cambridge dictionary defines a worksheet as "a piece of paper with questions and exercises for students". Another perspective is that "a worksheet is a piece of paper, a computer screen, or a projection that contains problems. These problems have right and wrong answers, and there is generally only one way to complete a problem" (Ransom & Manning, 2013, p. 188). Worksheets "include activities which give the students main responsibility in their own learning" (Yildirim et al., 2011, p. 45). Furthermore, according to Kurt (Atasoy et al., 2011) the worksheets "are very useful to observe and obtain results, can provide opportunity to reach new knowledge by way of student's own efforts, allow students to form hypothesis and do observation and experiment about a subject, help teachers to understand students' cognitive framework, can promote learning by doing and living, and keep students on task and make the learning fun" (p. 657).

Another point of view is that "worksheet serves to facilitate student's understanding in learning material by minimizing the role of teachers" (Nurrohmahadita, 2018, p. 142). In a pedagogical dictionary a worksheet is not defined but a workbook is. A workbook is defined as "a type of *cvičebnice*". *Cvičebnice* is defined as "type of textbook, the purpose of which is to repeat, consolidate certain knowledge, skills, creating habits etc." (Průcha et al., 2001, pp. 174 & 31). According to Ransom and Manning (2013) „the workbook is usually just a collection of worksheets with a glue on the spine" (p. 188).

A worksheet is a type of teaching material. Teaching material is "material or content that must be mastered by students through learning activities in accordance with the desired curriculum, arranged systematically, both written and not so as to create an environment or atmosphere that allows students to learn" (Fajriah & Suryaningsih, 2020, p. 1).

According to research (Podolak & Danforth, 2013) students favour the worksheets over textbooks and homework in a Modern Physics course. The research of Sulistiyowati et al. shows that "the application of STEM-based worksheet could effectively increase the science literacy" (Sulistiyowati et al., 2018, p. 89). Students' worksheets for integrated science were made for example by Widodo et al. for issues about motion in humans. The worksheets integrate students' knowledge about biology, physics, and chemistry. Students must integrate that knowledge to solve the problem (Widodo et al., 2018).

"Integrated science lesson is a natural science study whose study materials include biology, physics and chemistry as a whole" (Widodo et al., 2018, p. 2). The purpose of

https://doi.org/10.33225/BalticSTE/2021.07

that lessons is "to enable learners to connect the concepts contained in the three different disciplines and apply them in the real world experienced by learners in their daily lives" (Widodo et al., 2018, p. 2).

Authors define integrated science lessons as lessons that connect knowledge from chemistry, biology, physics, geography, and geology. In those lessons the students think about a topic from a different point of view – as a chemist, biologist, physicist, geologist, geographer. They should be as close to the real life as possible, and students should verify their theoretical knowledge in practice.

Since one of the reasons for not implementing integrated teaching into lessons is the lack of materials, we decided to make the teaching material (worksheets in particular) that teachers may use in their integrated (science) lessons. The question is how should a worksheet be designed?

In the first steps of creating a worksheet for integrated science that is discussed further, a mind map is a useful tool. By a mind map is meant "activities that work with associations" (Čapek, 2015, p. 333). "Mind mapping allows students to imagine and explore associations between concepts" (Davies, 2010, p. 280). One of the advantages of mind mapping is that it "promotes creative thinking" (Davies, 2010, p. 282). On the other hand, "types of links being made are limited to simple associations" (Davies, 2010, p. 282). When we want to make more complex connections, we may use concept maps.

Methodology for Creating Worksheets for Integrated Science

The content of worksheets must be based on the national Framework education program (hereinafter referred as FEP) for secondary general education (grammar schools). A method "CCCTER" that stands for "choose, connect (FEP with tasks and theory with practice), create, try, evaluate, remade" is a suitable method for creating worksheets for Integrated science and is further described.

The worksheet tasks were created by following these steps (choose and connect)

1) First, we chose one topic that is learned in chemistry. Five subtopics were chosen, each subtopic is a theme of one of the worksheets. Then we thought about how to teach each subtopic by integrated science teaching based on our experience as teachers. A suitable way of doing that was a mind map or a concept map.
2) In that in mind the expected outcomes of all subjects of educational area Man and Nature (that includes the following subjects: chemistry, biology, physics, geography, geology) as well as of the cross-curricular subject Environmental education, that could be connected to the topic, were chosen.
3) In phase three the chosen expected outcomes were connected to the tasks that aim to meet the given expected outcome or more expected outcomes. At least one of the tasks must connect theory with practice.

All worksheets are created according to the following criteria (create)

1) Each task of a worksheet must be connected to at least one expected outcome from all subjects in the educational area Man and Nature.
2) Each worksheet must contain at least five tasks. Each task is connected at least to one of the subjects of educational area Man and Nature (the tasks can be interdisciplinary).

https://doi.org/10.33225/BalticSTE/2021.07

3) Each worksheet must include laboratory work that can be inquiry based.
4) Each worksheet must contain such tasks in which there is a practical use of inter subject relations and context.
5) Each worksheet must respect active learning and activating methods of teaching because activating methods of teaching "enable the synthesis of the findings from various subjects and their usage in practical or didactically modified tasks or situations in a unique way" (Nováková, 2014, p. 5).
6) Each worksheet must contain different types of tasks from Tollingers' taxonomy.
    a. Tasks requiring memorable reproduction of knowledge e.g., *what is the weight of...* (Švec et al., 1996, p. 55)
    b. Tasks requiring simple cognitive operations with knowledge e.g., *determine the weight of...* (Švec et al., 1996, p. 56)
    c. Tasks requiring complex cognitive operations with knowledge e.g., *make a scheme of...* (Švec et al., 1996, p. 56)
    d. Task requiring transmission of knowledge e.g., *write brief content of...* (Švec et al., 1996, p. 57)
    e. Task requiring creative thinking e.g., *prove that...* (Švec et al., 1996, p. 57)

After the worksheets were created, the following steps proceed (try, evaluate, remade).

1) Worksheets were given a try in class with a sample of students. The feedback from students was given.
2) Worksheets were given to the experienced teachers for evaluation. The feedback was provided by an interview.
3) The feedback was processed and evaluated.
4) Worksheets were remade to be more suitable for students as well as for teachers.
5) The process of try, evaluate and remade can be repeated as many times as necessary.

Outcome

The example of choose, connect, and create put into practice is given.

Phase one - choose

First, one topic that is learned in chemistry was chosen – Halogens. Then authors reflected about their experience as teachers and thought about how this topic can be taught by integrated science learning. A mind map was made (see Figure 1 part 1 and part 2). As shown in the mind map, several connections among subjects can be made. For example, when teaching about yperite teachers can combine history (World War I) with chemistry (chemical compound) and biology (physiological effects) as well as with geography (Ypres, Belgium). Polyvinyl chloride can be thought from a chemist's perspective (chemical compound, polymer) as well as ecologist's (environmental pollution and sustainability). Sodium chloride is an important chemical compound (chemistry) with specific properties (physics), that plays an important role in our body

https://doi.org/10.33225/BalticSTE/2021.07

(biology) and is an important component of The Dead Sea (geography). That is why topic Halogens is suitable for integrated lesson.

From the mind map five subtopics emerged. The subtopics were named as Halogens and plastics, Halogens and the ozone layer, Halogens and their cycle, Halogens and We, Halogens and their structure. After several discussions there was a need to "unchemistry" them in their titles so they will be judged by their content and not through their titles. New titles of the subtopics were Plastics, Ozone layer, Chlorines' cycle, Halogens in our hands, and Look for structure behind everything.

Phase two - connect

The expected outcomes of all subjects of educational area Man and Nature as well as of the cross-curricular subject Environmental education, that could be connected to these subtopics were chosen and connected with the tasks. An example is given on the following task that is part of a subtopic Plastics.

Expected outcome – Physics: The pupil shall distinguish between scalar and vector quantities and employ them while solving physical problems and exercises (Research Institute of Education in Prague, 2007, p. 27).

Expected outcome – Chemistry: The pupil shall characterise the basic groups of organic compounds and their significant representatives, evaluate their raw material sources, their application in practice and their effect on the environment (Research Institute of Education in Prague, 2007, p. 30).

Phase three - create

The task introduction:

One of the ways to dispose of PVC is to burn it. By burning PVC, energy is obtained. Its calorific value is 22.5 MJ per kilogram. Calorific value is a property of fuel that indicates how much energy is released by completely burning one unit, which is usually kg. By burning one kilogram of PVC, we get energy of 22.5 MJ. This energy can be converted to kWh according to the relation $1\ J = 2{,}778 \cdot 10^{-7}$ kWh.

The task:

For how long will a light bulb light with a use of energy of 0.006 kW per hour for which energy will be obtained by burning 1 kg of PVC? The calorific value of PVC is 22.5 MJ / kg.

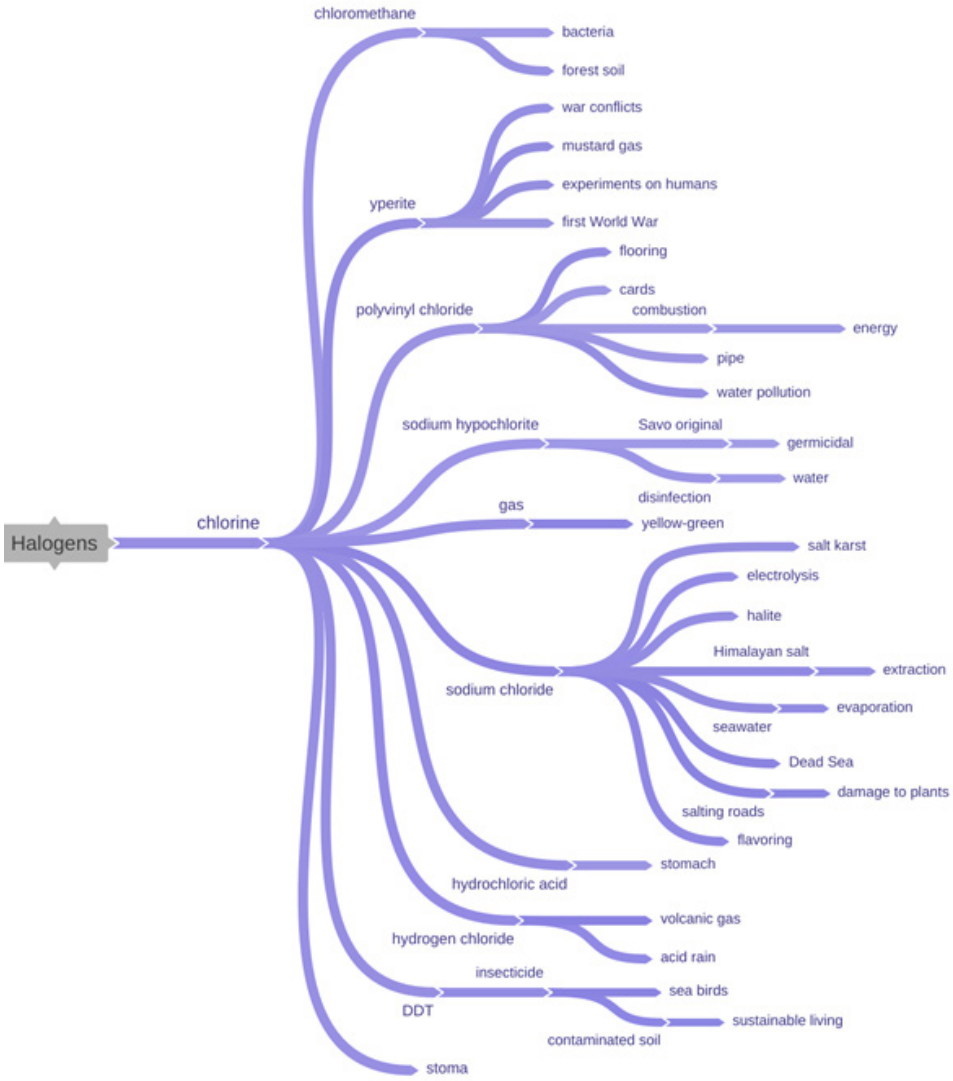
https://doi.org/10.33225/BalticSTE/2021.07

Figure 1a

Mind Map "Halogens" (Mind map was made using Coggle https://coggle.it/)

https://doi.org/10.33225/BalticSTE/2021.07

Figure 1b
Mind Map "Halogens" (Mind map was made using Coggle https://coggle.it/)



Conclusions and Implications

Based on previous research one of the main reasons for not implementing integrated teaching into lessons is a lack of suitable teaching materials. In this contribution new method that can be used for making integrated worksheets for all subjects of educational area Man and Nature is described with a practical example. A united method for making worksheets for integrated (science) teaching is important so a database of worksheets for integrated (science) teaching can be made and one of the main obstacles for not implementing integrated teaching into lessons (lack of suitable materials) can be overcome.

https://doi.org/10.33225/BalticSTE/2021.07

Acknowledgements

This article was elaborated within the activities in support of study programs specifically focused on the preparation of teachers with deficit teaching specialization at non-pedagogical faculties of public universities financed from the institutional support of the Ministry of Education, Youth and Sports for 2021.

Declaration of Interest

Authors declare no competing interest.

References

Atasoy, S., Kucuk, M., & Akdeniz, A. R. (2011). Remedying science student teachers' misconceptions of force and motion using worksheets based on constructivist learning theory. *Energy Education Science and Technology Part B: Social and Educational Studies, 3*(4), 653-668.

Bartoňová, M., & Kričfaluši, D. (2020). Názory a povědomí učitelů Moravskoslezského kraje o integrované výuce a její realizaci na středních školách. [Opinions and Awareness of Moravian-Silesian Region Teachers Regarding Integrated Teaching and Its Implementation at Secondary Schools]. *Biologie-Chemie-Zeměpis, 29*(4), 13-23. https://dx.doi.org/10.14712/25337556.2020.4.2

Cambridge University Press. (2021, June 17). *Worksheet*. Cambridge Dictionary. https://dictionary.cambridge.org/dictionary/english/worksheet

Čapek, R. (2015). *Moderní didaktika: Lexikon výukových a hodnoticích metod.* [Modern didactics: Lexicon of teaching and assessment methods]. (1st edition). Grada Publishing.

Davies, M. (2010). Concept mapping, mind mapping and argument mapping: what are the differences, and do they matter? *Higher Education*, *62*, 279-301. https://doi.org/10.1007/s10734-010-9387-6

Fajriah, N., & Suryaningsih, Y. (2020). The development of constructivism-based student worksheets. *Journal of Physics: Conference Series, 1470*. http://dx.doi.org/10.1088/1742-6596/1470/1/012011

Fogarty, R. (1991). Ten ways to integrate curriculum. *Educational Leadership, 49*, 61-65.

Nováková, J. (2014). *Aktivizující metody výuky*. [Activating methods of teaching]. Univerzita Karlova v Praze, Pedagogická fakulta.

Nurrohmahadita, W. (2018). Worksheet development with the problem-solving methods at grade IV of elementary school students. *Advances in Social Science, Education and Humanities Research, 212*, 142-145. https://dx.doi.org/10.2991/icei-18.2018.31

Podolak, K., & Danforth, J. (2013). Interactive modern physics worksheets methodology and assessment. *European Journal of Physics Education, 4*(2), 27-31. https://eric.ed.gov/?id=EJ1052310

Průcha, J., Walterová, E., & Mareš, J. (2001). *Pedagogický slovník.* [Pedagogical dictionary] (3rd edition). Portál.

Rakoušová, A. (2008). *Integrace obsahu vyučování v primární škole: Integrované slovní úlohy napříč předměty.* [*Integrating the content of teaching in primary school: Integrated word problems across subjects*] (1st edition). Grada Publishing.

Ransom, M., & Manning, M. (2013). Worksheets, worksheets, worksheets. *Childhood Education*, *89*(3), 188-190. https://doi.org/10.1080/00094056.2013.792707

Research Institute of Education in Prague – VÚP, (2007). *Framework education programme for secondary general education (grammar schools)*.

Sulistiyowati, Abdurrahman, & Tri Jalmo. (2018). The effect of STEM-based worksheet on students' science literacy. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *3*(1)*,* 89-96. https://doi.org/10.24042/tadris.v3i1.2141

Švec, V., Filová, H., & Šimoník, O. (1996). *Praktikum didaktických dovedností*. [*Practicum of didactic skills*]. Masarykova univerzita v Brně.

Widodo, W., Sudibyo, E., & Sari, D. A. P. (2018). Analysis of expert validation on developing integrated science worksheet to improve problem solving skills of natural science prospective teachers. *Journal of Physics: Conference Series, 1006.* http://dx.doi.org/10.1088/1742-6596/1006/1/012026

Yildirim, N., Kurt, S., & Ayas, A. (2011). The effect of the worksheets on students' achievement in chemical equilibrium. *Journal of Turkish Science Education, 8*(3), 44-58.

Received: *May 22, 2021* Accepted: *July 24, 2021*

Cite as: Bartoňová, M., & Kričfaluši, D. (2021). The methodology for creating worksheets for integrated science. In. V. Lamanauskas (Ed.), *Science and technology education: Developing a global perspective. Proceedings of the 4th International Baltic Symposium on Science and Technology Education (BalticSTE2021)* (pp. 7-15). Scientia Socialis Press. https://doi.org/10.33225/BalticSTE/2021.07